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REMARKS

In view of the following discussion, the Applicants submit that none of the claims now pending in the application is anticipated under the provisions of 35 U.S.C. § 102 or made obvious under the provisions of 35 U.S.C. § 103. Thus, the Applicants believe that all of these claims are now in allowable form.

I. REJECTION OF CLAIMS 1 AND 21 UNDER 35 U.S.C. § 102/§ 103

Claims 1 and 21 stand rejected under of 35 U.S.C. § 102 as being anticipated by or, in the alternative, under of 35 U.S.C. § 103 as obvious over Shirane et al. (United States Patent Application Publication No. 2002/0146196, published October 10, 2002, hereinafter "Shirane"). The Applicants respectfully traverse both types of rejections.

Shirane teaches an optical switch having a photonic crystal structure. In particular, the switch includes a core photonic crystal layer sandwiched between two layers of dielectric material. The photonic crystal layer includes a line-defect optical waveguide. An n-type region is formed adjacent to a portion of one side of the line-defect waveguide, while a p-type region is formed adjacent to a portion of the opposite side of the line defect region. The n-type region includes an n-type ohmic electrode, while the p-type region includes a p-type ohmic electrode.

The Examiner's attention is respectfully directed to the fact that Shirane fails to teach, show or suggest the novel invention of positioning lateral electrical contacts to provide electrical control along substantially an entire length of a waveguide, as positively claimed in the Applicants' independent claims 1 and 21. Specifically, Applicants' claims 1 and 21 recite:

> 1. An apparatus comprising:
> a photonic crystal having a layer where light is guided or is confined; and
> at least one lateral electrical contact coupled to said layer of the photonic crystal, said at least one lateral electrical contact positioned to provide electrical control along substantially an entire length of said layer. (Emphasis added)

21. A method for applying electrical control to a photonic crystal structure comprising:

providing a photonic crystal having a layer where light is guided;

coupling at least one lateral electrical contact to said layer of the photonic crystal, said at least one lateral electrical contact positioned to provide electrical control along substantially an entire length of said layer; and

applying a voltage to the at least one lateral electrical contact. (Emphasis added)

The Applicants' invention is directed to a method and apparatus for forming lateral electrical contacts for photonic crystal devices. To date, it has proven extremely difficult to combine electrical control with high refractive index, high confinement systems without distorting the optical field and inducing unwanted absorption. Thus, efforts to integrate electronic control with photonic crystal devices are confronted with two competing concerns: (1) the need to place electrical contacts as close to the optical mode as possible to achieve optimal control; and (2) the need to space the electrical contacts far enough away from the optical mode to minimize distortion and absorption.

The Applicants' invention addresses these concerns by providing a photonic crystal structure including a substrate having a plurality of rows of apertures formed therethrough (creating a lattice) and a waveguide (where incident light is guided or confined) formed through the lattice (*e.g.*, by removing one or more rows of apertures). The photonic crystal structure further includes a pair of lateral electrical contacts, each contact being positioned laterally relative to one side of the waveguide and spaced a distance away from the waveguide by at least one row of apertures that optically isolates that contacts from the waveguide. The contacts each extend along substantially the entire length of the waveguide, thereby providing a means for electrical control along the entire length. By applying voltages to the contacts, effects such as thermo-optic control of the waveguide, current injection and other photonic crystal applications can be achieved.

By contrast, Shirane provides only regional electrical control of the waveguide. That is, as best as can be understood from Shirane's disclosure and Figures (*i.e.*, Figures 11 and 12), the n- and p-type ohmic electrodes are positioned to provide current only along localized portions of the line-defect optical waveguide. The photonic crystal device claimed by the Applicants provides superior electrical control of a photonic crystal waveguide by positioning lateral electrical contacts along substantially the entire length of the waveguide, thereby achieving more consistent thermo-optic control along the length of the waveguide. The consistency of such an approach is preferable for applications such as photodetection, high-frequency switching and optical modulation, among others. Shirane does not teach, show or suggest positioning lateral electrical contacts along the sides of a photonic crystal waveguide in such a way as to provide electrical control over substantially the entire length of the waveguide, as claimed by the Applicants in independent claims 1 and 21.

The Examiner states in paragraph 2 of the Final Office Action that the applicability of 35 U.S.C. § 102 or 103 depends on the interpretation of the claim's recitation of "at least one electrical contact positioned to provide electrical control along substantially **an** entire length of said layer. The electrodes of Shirane (e.g., 80 or 81) are taught to provide electrical control along an entire length – i.e., the entire length of the electrodes – of the waveguide (e.g., 77) layer. " The Applicants submit that the phrase "....along substantially an entire length of said layer" refers to the length (i.e. lateral dimension) of the layer, and not the length of the lateral electrical contact itself. That is, the Applicants submit that the lateral electrical contact is positioned in a manner that extends substantially along the entire length of the layer that the contact is coupled to. The Applicants further submit that the claim could have possibly been phrased as "along substantially **the** entire length of said layer", but chose otherwise due to the potential confusion caused by the lack of antecedent basis. Consequently, the Applicants submit that claims 1 and 21 are not anticipated by Shirane under 35 U.S.C. § 102.

The Examiner similarly alleges that if the claims are interpreted as necessitating the electrodes to extend along the entire waveguide in the claimed device, then a 35 U.S.C. § 103 rejection would be appropriate. The Examiner states that Shirane does not explicitly recite that the electrodes are positioned substantially along the entire length of the waveguide layer and that the electrodes provide electrical control in the waveguide. However, the Examiner also states that it would have been obvious to one of ordinary skill in the art at the time of the invention to extend at least one electrode to cover the entire length of the waveguide in Shirane because this would allow a larger region of the waveguide to be switched on/off. The Applicants submit that Shirane does not provide any motivation or suggestion to laterally extend the at least one electrode as claimed in the present invention. Namely, Shirane states in paragraph [0072] that:

> When current is injected or a reverse bias voltage is applied between the electrodes 80 and 81, the photonic band structure of the photonic crystal around the line-defect optical waveguide changes, by which the propagation mode of the line-defect waveguide becomes to be outside the photonic band gap, whereby light can no longer propagate through the line-defect waveguide. (Emphasis added)

This paragraph cited by the Examiner simply states that it is possible to prevent light from propagating through the line-defect waveguide when a current or reverse bias voltage is applied between electrodes 80 and 81. Notably, there is no motivation or suggestion in Shirane to position the electrodes in a lateral manner as claimed in the present invention since the current configuration in Shirane achieves all the aspects (either presented or contemplated) of the invention taught by Shirane as evidenced by paragraph [0072]. In other words, the length of the electrodes is not disclosed or suggested in any manner whatsoever in relation to the prevention of the propagation of light through the waveguide. More specifically, Shirane does not provide any mention or suggestion that the prevention of light through the line-defect waveguide can be better achieved by increasing the length of the electrodes or the lateral positioning of the electrodes as specified in claims 1 and 21. Furthermore, the Applicants submit that the Examiner cannot use the Applicants' invention as motivation or suggestion for the obvious rejection. The Applicants respectfully submit that the Examiner is using the advantages achieved by the present invention and hindsight to support his obviousness rejection.

As mentioned above, the Applicants' specification states that the electrical contacts are placed in a manner that ensures there will be minimal absorption losses even if the contacts are formed from a metal or other materials with high absorption losses. The deployment of lateral contacts is a significant advancement over existing photonic crystal designs, as it allows for electrical control over the photonic crystal device without significant absorption of light by the contacts. Notably, Shirane does not provide any suggestion or motivation to achieve this advantage offered by the present invention. Rather, Shirane only addresses that the propagation of light through the waveguide may be prevented. Therefore, the Applicants respectfully submit that claims 1 and 21 are not made obvious by Shirane under 35 U.S.C. § 103.

Therefore, the Applicants submit claims 1 and 21 fully satisfy the requirements of both 35 U.S.C. §102 and §103 and are patentable thereunder.

II. REJECTION OF CLAIMS 1-15 AND 21-31 UNDER 35 U.S.C. § 103

1. Claims 1-15 and 21-31

Claims 1-15 and 21-31 stand rejected as being obvious over Shirane. In response, the Applicants respectfully traverse the rejection.

As discussed above, Shirane does not teach, show or suggest positioning lateral electrical contacts along the sides of a photonic crystal waveguide in such a way as to provide electrical control over substantially the entire length of the waveguide, as claimed by the Applicants in independent claims 1 and 21. As such, the Applicants submit that claims 1 and 21 are not made obvious by the teachings of Shirane. Therefore, the Applicants submit claims 1 and 21 fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

Claims 2-15 and 22-31 depend from claims 1 and 21 and recite additional limitations therefore. Accordingly, and for at least the same reasons set forth above, the Applicants respectfully submit that claims 2-15 and 22-31 also are not made obvious by the teachings of Shirane. Therefore, the Applicants submit claims 2-15 and 22-31 also fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

2. Claims 16-20

Claims 16-20 stand rejected as being obvious over Shirane in view of the Baba et al. patent (United States Patent No. 6,522,448, issued February 18, 2003, hereinafter "Baba"). In response, the Applicants respectfully traverse the rejection.

As discussed above, Shirane does not teach, show or suggest positioning lateral electrical contacts along the sides of a photonic crystal waveguide in such a way as to provide electrical control over substantially the entire length of the waveguide, as claimed by the Applicants in independent claim 1. Baba does not bridge this gap in the teachings of Shirane. As such, the Applicants submit that claim 1 is not made obvious by the teachings of Shirane in view of Baba. Therefore, the Applicants submit claim 1 fully satisfies the requirements of 35 U.S.C. §103 and is patentable thereunder.

Claims 16-20 depend from claim 1 and recite additional limitations therefore. Accordingly, and for at least the same reasons set forth above, the Applicants respectfully submit that claims 16-20 are also not made obvious by the teachings of Shirane in view of Baba. Therefore, the Applicants submit claims 16-20 also fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

3. Claims 32-36

Claims 32-36 stand rejected as being obvious over Shirane in view of the Montgomery et al. patent (United States Patent No. 6,845,198, issued January 18, 2005, hereinafter "Montgomery"). In response, the Applicants traverse the rejection. Notably, independent claim 32 recites:

> 32. A method for thermo-optic control of a photonic crystal structure comprising:
> providing a photonic crystal comprising:
> a substrate;
> a plurality of apertures formed through the substrate; and
> a waveguide formed through the plurality of apertures, substantially proximate to the middle of the substrate;
> forming a first lateral electrical contact proximate to the waveguide, the first lateral electrical contact being optically isolated from the waveguide by the plurality of apertures;
> forming a second lateral electrical contact proximate to the waveguide, the second lateral electrical contact being optically isolated from the waveguide by the plurality of apertures, said first lateral electrical contact and said second

> lateral electrical contact being positioned to provide electrical control along substantially an entire length of said layer; and
> sequentially heating and cooling the substrate. (Emphasis added)

As discussed above, Shirane does not teach, show or suggest positioning lateral electrical contacts along the sides of a photonic crystal waveguide in such a way as to provide electrical control over substantially the entire length of the waveguide, as claimed by the Applicants in independent claim 32. Montgomery does not bridge this gap in the teachings of Shirane. As such, the Applicants submit that claim 32 is not made obvious by the teachings of Shirane in view of Montgomery. Therefore, the Applicants submit claim 32 fully satisfies the requirements of 35 U.S.C. §103 and is patentable thereunder.

Claims 33-36 depend from claim 32 and recite additional limitations therefore. Accordingly, and for at least the same reasons set forth above, the Applicants respectfully submit that claims 33-36 are also not made obvious by the teachings of Shirane in view of Montgomery. Therefore, the Applicants submit claims 33-36 also fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

III. REJECTION OF CLAIMS FOR OBVIOUSNESS-TYPE DOUBLE PATENTING

Claims 1-36 stand provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-19 of co-pending Application no. 10/755,816 as well as claims 1-19 of co-pending Application no. 11/122,152.

Responsive to the Examiner, Applicants enclose two (2) terminal disclaimers. It is respectfully requested that the rejection of claims 1-36 under the doctrine of obviousness-type double patenting be withdrawn.

IV. CONCLUSION

Thus, the Applicants submit that all of the presented claims fully satisfy the requirements of 35 U.S.C. §102, 35 U.S.C. §103, and the judicially created doctrine of obviousness-type double patenting. Consequently, the Applicants believe that all of the presented claims are presently in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issue are earnestly solicited.

If, however, the Examiner believes that there are any unresolved issues requiring the maintenance of the present final action in any of the claims now pending in the application, it is requested that the Examiner telephone Mr. Kin-Wah Tong, Esq. at (732) 530-9404 so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

Respectfully submitted,

9/6/06
Date

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